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ENTOMOLOGICAL PHASES OF SALVAGE LOGGING PROJECTS

SEASON OF 1935

by

K. A. Salman and P. C. Johnson
Berkeley, California
March 16, 1936

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INTRODUCTION

The logging of insect killed or insect infested trees for the purpose of utilizing values that otherwise would be destroyed, is not a new development. The logging and utilization of insect infested timber also has been tried as a method of combatting forest insect depredations. However, logging and utilization of insect infested material has not become a generally accepted phase of the practice of forest management in California.

In the east side areas of California the recent heavy losses that have been resulting in continued depletion of pine stands have created a considerable amount of interest in the possibilities of the salvage logging method. These infestations have not responded satisfactorily to direct control measures. The area of heavy infestation has been so large that there has been no practical possibility of cutting and placing on the market the great volume of timber it would be necessary to harvest under any effective method of selective cutting practice.

Salvage logging was one alternative that was considered. It was hoped that, where possible, some values could be utilized and infestations might be reduced. It was not hoped to attain any permanent modification of the stands that might react to their benefit. However, as the work progressed, possibilities of a considerable amount of prevention of loss were indicated. The chief objectives of this method are (1) to prevent the total loss of infested materials through utilization before the loss of values becomes too great and (2) to secure some measure of control of forest insect infestations. Under the economic and infestation conditions that exist in east side areas it is considered that, until more is known of forest insect infestations, there is no sound basis on which to build a method utilizing more advanced principles.

RECENT SALVAGE LOGGING PROJECTS

The use of the salvage logging method in regulating infestation conditions was recommended in 1925 by Berry and Hughes (1*) for the Pickering Sale area in the Modoc National Forest. Keen (2*) has given some information on the amount of work done as a result of those recommendations.

In 1934 the McCloud River Lumber Company used salvage logging methods in controlling infestations on their own lands in the southeastern

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1* Berry, J. N. and Hughes, E.O. Report on Western Pine Beetle Situation and the Appraisal of the Timber Values in the Badger Springs Unit, Modoc National Forest. June 7, 1928.

2* Keen, F. P. Western Pine Beetle Survey, Happy Camp-Lava Beds Area, Modoc National Forest. Eighth Annual Survey, December 1, 1929.

part of the Shasta National Forest. They logged and utilized 2,803 M.B.M. in that year. In 1935 the company requested, and obtained an administrative use permit to log and utilize abandoned and infested trees on intermingled company and government lands in the western portion of the Modoc National Forest. In the same year the Fruit Growers Supply Company obtained permission to stop cutting in the stands of the Eastern Lassen Working Circle that were under contract to them. The permission was granted with the stipulation that they salvage and log infested trees on a certain portion of that area.

COOPERATION

The 1935 Fruit Growers Supply Company's project was chiefly an experimental one. Accordingly, the Forest Service and the Bureau of Entomology and Plant Quarantine cooperated with the company in studying the practicability and effectiveness of the salvage logging method. The Bureau also studied the entomological phases of the 1935 McCloud project. Details of the cooperation given by the several organizations that carried on the studies and work on the two project areas are as follows:

Fruit Growers Project:

On this project the Regional Office and the Lassen National Forest arranged to do the spotting, supervise the logging according to Forest Service standards and to make time studies and observations on field methods. In addition, they ran a green chain tally of a sample run of logs in the mill at Susanville. They tabulated the costs of the project, the values represented in the logs, and the amount of degrade resulting from insect attacks. This information has been presented in two reports. The first, by Berry (3*) has to do with the results of the time and mill studies. The second, by Parker (4*) covers the field work.

The Fruit Growers Supply Company provided the men and equipment for the actual logging and did the work. They also cooperated in providing facilities for the logging andmill studies.

The California Forest and Range Experiment Station, Office of Forest Products, studied the dried lumber grades. They are now working up the values and loss in values due to the factors associated with insect attack.

The Bureau of Entomology and Plant Quarantine, Division of Forest Insect Investigations aided to some extent in the spotting. In addition, complete infestation records were taken for each study tree and all study logs were marked before transporting them to the mill. Cruises that were made on a 320-acre plot tabulated the 1934 and the partial 1935 seasonal losses for comparison with loss figures from other plots.

3* Berry, J. S. Lumbering Studies, Fruit Growers Supply Company (Beetle-Killed Timber) Timber Management. July 24, 1935

4* Parker, Veldon. Report on Salvage Operation of Beetle Infested Pine Timber, Lassen National Forest, Summer of 1935.

McCloud Project:

On this project area the company provided the equipment and personnel for the field work. A Forest Service officer was provided for from cooperative funds set up by the company. The records secured by him were summarized in a report by Bacon (5*). No attempt was made to conduct a logging or mill study on this project. However, the Bureau of Entomology and Plant Quarantine set up a 320-acre study plot and secured records similar to those obtained on the Fruit Growers Project area.

INFESTATION CONDITIONS

Fruit Growers Project:

In preliminary work done on this project many abandoned trees were marked for salvage in order to determine if the salvageable values that could be recovered from them would pay for the cost of logging and manufacture. In addition, a few topkilled trees were marked at the start of the work to determine if the amount of infestation in them was sufficient to justify felling and utilization before further infestation or degrade occurred. It was found that the degrade in material from abandoned trees was too great to justify their utilization and that not a sufficiently large amount of infested material was taken from topkilled trees to justify their removal from a direct control standpoint. As a result, the greater portion of the logs handled on this project were from trees very much like those that would ordinarily be treated on direct control projects.

Impressions gained from a detailed study of the composition of infestation on the sample plot in the salvage area are that the infestation was still rising. It had not reached its peak by the time the work was done. This conclusion is based on the fact that the majority of the infested ponderosa and jeffrey pine trees contained infestations in which the western pine beetle and the jeffrey pine beetle followed previous attacks by flatheaded borers and engraver beetles in the tops of the trees.

McCloud Project:

In this area no topkilled trees were taken. Although some abandoned trees were removed along with the infested trees, none were taken unless it was considered that sufficient salvageable values existed in them.

The infestation in the pure ponderosa pine stand was primarily one caused by the western pine beetle. The infestation cycle was at its peak. This conclusion has been reached from a study of detailed analyses of the infestation. In the fall of 1934 pure mid-bole and strip kill attacks by that species were the predominating elements of the infestation. In the spring of 1935 the green areas of phloem in the tops and bases of infested trees as well as those areas left uninfested by the strip kills were filling in with 1935 broods. Ips oregoni, Ips emarginatus and Dendroctonus brevicomis were the insects chiefly concerned in the 1935 attacks.

5* Bacon, R. S. Report on Whitehorse Insect Control Project, 1935. November 27, 1935.

Several small groups of trees were attacked by the first seasonal generation of the western pine beetle. In addition to these types of infestations, the very susceptible type in which the trees had suffered primary topkilling attacks by previous generations of flathead borers was very numerous in the sample.

STAND CONDITIONS AND PROJECT FIGURES

Marked differences are to be found in several phases of the work done on the two projects. For the most part these have been covered in the reports by Bacon, Berry and Parker. However, for the benefit of those to whom these reports are not available, the following salient features of the projects have been presented in a brief form.

	Fruit Growers Project	McCloud Project
Location	Lassen National Forest	Modoc National Forest
Specific Location	See Figure 1	See Figure 2
Tree Species Involved	Ponderosa & Jeffrey Pine	Ponderosa pine
Site Quality	III	III-IV
Acreage	6010	8000
Period of Work	May 22-October 11,1935	April 9-July 10, 1935
Volume Salvaged	2,151 MBM ponderosa 505 MBM Jeffrey 2,656 MBM Total	2,300 MBM ponderosa
Felling and limbing	Gypo - in woods	Day labor - in woods
Bucking	Gypo - at landing	Day labor - in woods
Logging Roads (Truck Trails)	None constructed	Cat and Bulldozer
Methods of yarding	Tree length	Log lengths
Yarding equipment	Cat and arch	Cat and arch
Yarded at	Railroad in trainloads	Truck roads in truck loads
Method of loading	Crane to flatcars	Cross haul to trucks
Transportation to pond	Rail to Susanville	Gypo trucks to mainline, train to McCloud.
Costs per MBM (Basis probably not comparable.)	$3.10 (logging) $8.71 (to pond)	$9.46 (on cars)

SPOTTING METHODS

A three-man spotting crew was used on each of the projects. They covered the entire area once. Another coverage was secured by another intensive spotting done by the Forest Service representative. This work was done in connection with the felling and resulted in almost complete spotting of merchantable infested trees.

Parker (loc. cit) has suggested, and in some respects we concur in his suggestion, that spotting be done just ahead of the fallers. Although spotting ahead, in the spring season, results in the marking of many trees that will be abandoned by the time the operation reaches them it is possible that some infestation conditions or some seasonal conditions may allow a considerable time interval between spotting and felling. Light infestations

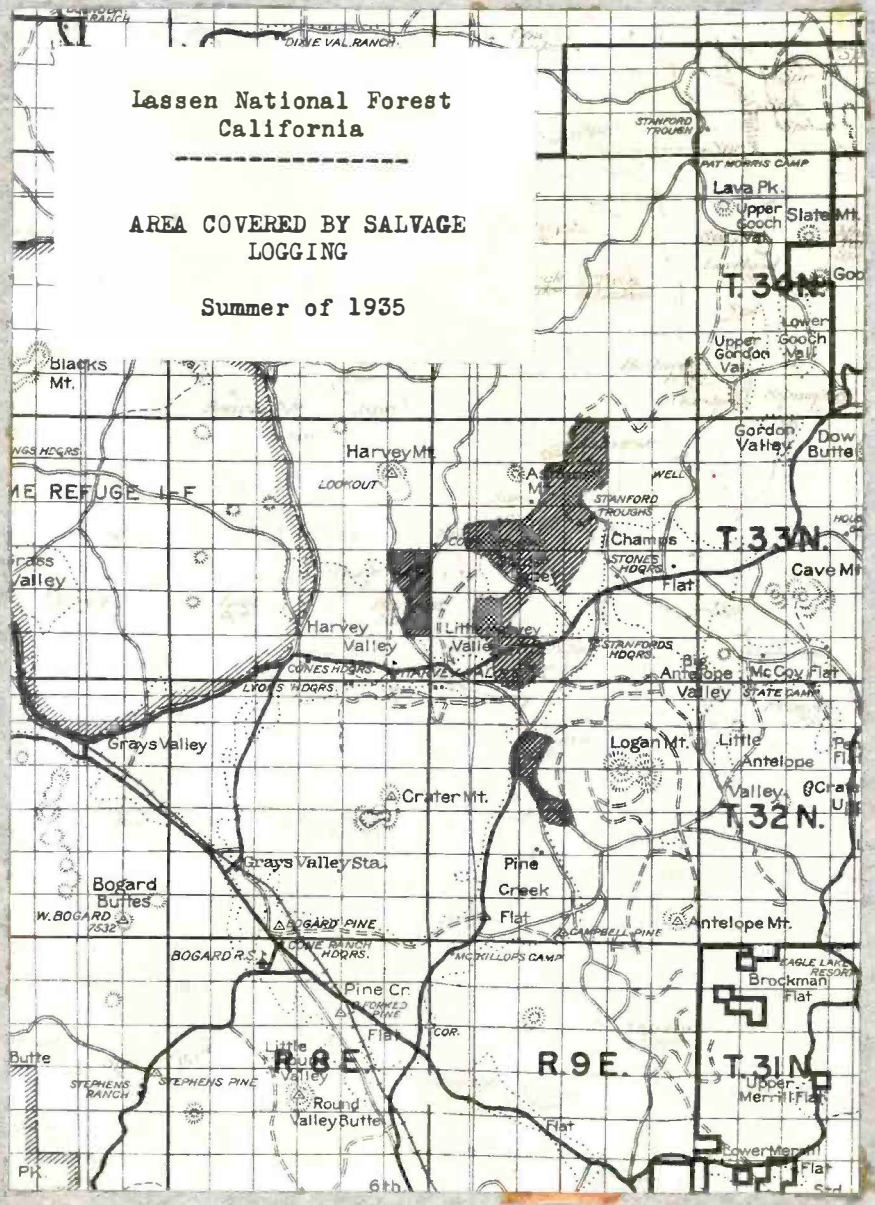


Figure 1

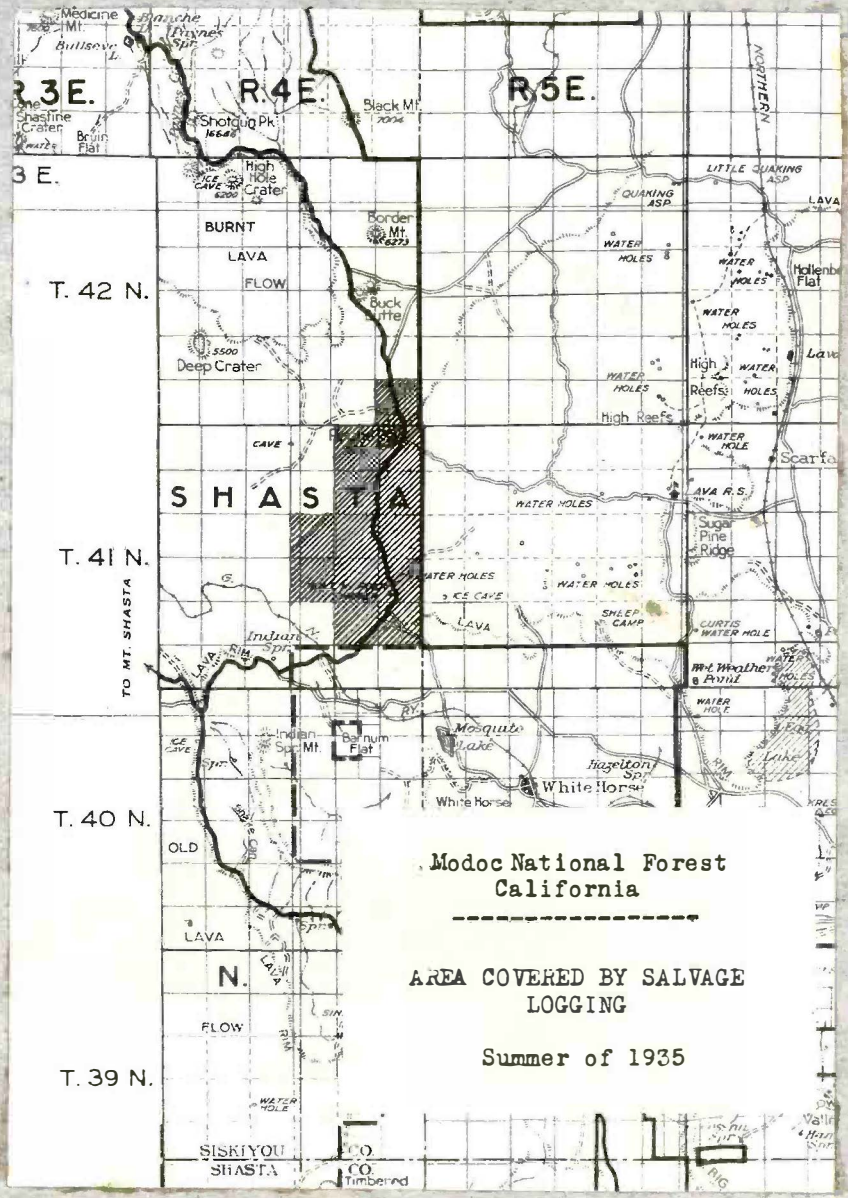


Figure 2

may make it necessary to have a considerable margin of area and time in order to maintain the proper relations between spotting and felling.

LOGGING METHODS

Except for the fact that infested trees were the only ones taken, the logging methods used on the McCloud Project area were about the same as would be used on any regular logging project in which a truck haul was necessary. Plate 1 illustrates some of the methods used on this project. (See p.7).

On the Fruit Growers project some interesting deviations from the standard methods of logging used in this region were tried experimentally. As the trees were felled, they were limbed and bucked to the merchantable top diameter limit. Yarding was done in tree lengths. Because of this, and the fact that excessive damage to reproduction could not be allowed, it was necessary that they be felled at a satisfactory angle to the main skidways that had been laid out in advance. The cat hooked the individual trees, preferably at the butt end, and dragged them to the edge of the main skidway. At that point it dropped the tree to secure others to complete the load. The complete load, when assembled along the main cat trail, was taken directly to the landing where it was dropped in a position that made it possible to buck the trees into log lengths with a minimum amount of handling by a light-tractor and bulldozer. The several phases of this work are shown in Plate 2. (See p. 8).

By felling and hauling the logs in this manner it was possible to eliminate all but a minimum amount of injury to reproduction in snaking the trees from their beds to the main cat trails. The use of main cat trails also caused a minimum amount of damage to living trees. However, it was found that straight trails were necessary in tree length logging. This sometimes resulted in the breaking down of reproduction where it was impossible to go around dense thickets. Plates 4, 5, and 6 which are to be found at the end of this report show the amount of damage caused by using main cat trails and illustrates the loading and yarding processes.

ENTOMOLOGICAL STUDY METHODS

On the Fruit Growers project area a 320-acre plot was established in the south half of Section 17, T. 33N., R. 9E. On the McCloud project area a similar plot was established in the west half of Section 24, T. 41N., R.4E. Losses of the previous season and of the 1935 season were cruised on these plots. Comparisons with untreated areas were supplied by nearby regional survey plots.

Salvaged trees were examined as felled and a complete picture of the infestation in each one was secured on a stem analysis form. In addition, other data, ordinarily secured in forest insect surveys, were secured. Accurate measurements of all different infestation combinations in each tree were taken to form a basis for bark surface calculations. Records of 111 trees were secured from the McCloud Project area. 292 records were taken on the Fruit Growers Project.

PLATE 1

A

B

C

D

LOGGING METHODS - McCLOUD PROJECT

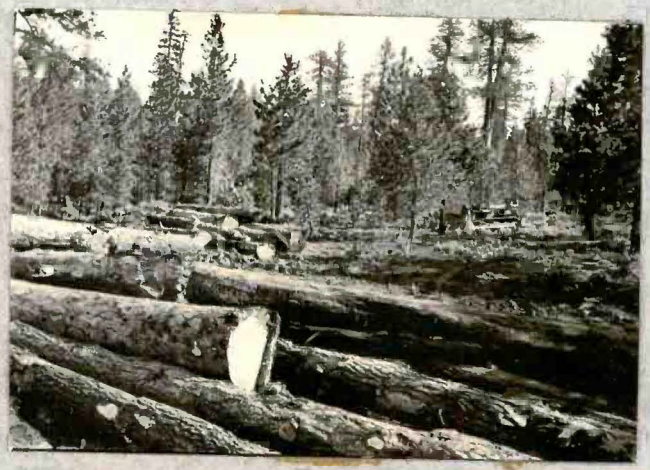
Trees were felled, limbed and bucked into log lengths in the woods. The cat was brought alongside and bunched the logs in each tree (Fig.A) to form a load. Each cat load was dragged to a point where trucks could be brought (Fig.B). Sometimes this meant travel over the rough lava flows and reefs. Trucks were brought to the logs along rough truck trails constructed on the job (Fig.C). Here, by use of a tractor, cable, and skids, the load was placed on them by means of the cross haul method. (Fig.D).

PLATE 2

A

B

C



D

LOGGING METHODS - FRUIT GROWERS PROJECT

The trees were snaked from their beds after being felled (Fig. A) and taken to the main cat trail. Sometimes fallen snags, stumps, and rocks hampered the work considerably - fallen snags being the more abundant hazard in this area. On the cat trail the loads were gathered and taken down the main trail (Fig. B, C) to the landing beside the railroad (Fig. D). There they were spaced for bucking, either by hand, or with a Dow saw. In loading, a small bulldozer shown in Figure D, was used to bunt them within reach of the crane.

OBJECTIVES OF THE ENTOMOLOGICAL WORK

The field work was designed to secure data that would be applied in attaining the following objectives:

1. To secure data on the infestations and brood stages present in each study log in order to supply a basis for determining the decrease in values or the amount of cull as it may be related to insect species or stages of development of broods.

2. To determine if the data secured during spotting or by spotting methods can be used to judge the values in infested trees or to eliminate low salvage values without felling the trees.

3. To determine the effectiveness of the salvage operation in removing infested bark surface from the salvage area.

4. To observe the degree of success of the broods left in infested bark on tops and chunks.

5. To secure loss figures and supply a basis for judging the control values secured on these projects that presumably result from the work.

The information gathered in the course of this study has been discussed in relation to the above objectives and in the order as given above.

RELATION OF ENTOMOLOGICAL FACTORS AND CULL

This relation has been shown by Berry (loc.cit.) on the basis of a comparison of degrade in the logs used in the Fruit Growers mill study with the infestation conditions in those logs.

He compared the relation of amount of deduction due to bluestain and the season of attack of the oldest brood involved in the attack. His results, when averaged, were as follows:

No. of trees	Season of Brood	Average Bluestain Deduction (%)
25	1934 Summer	39.8
69	1934 Winter	36.1
10	1935 Summer	11.7

Slight differences were found in the degrade present in ponderosa pine and Jeffrey pine trees but no attempt has been made to show these differences in the above table. Berry also studied the relation of brood stages to degrade. That relation is shown in the following table. Broods that were primarily in the pupal, new adult or abandoned phases of infestation were grouped together in his comparison. That was done because of the fact that the bluestain deduction was large in logs bearing infestations that were that far advanced.

Relation of Brood Stages and Bluestain Deductions (Spring, 1935)

No. logs	Brood Stages	Average Bluestain Deduction (%)
54	Attack, parent adults, eggs 0-½ larvae	9.6
52	0-½ larvae and ½-1 larvae	23.7
232	Few ½-1 larvae, pupae, new adults and abandoned	47.1

In addition to these classes of infested material several types of infestations produce some green logs or logs in which a new attack had not progressed beyond the formation of galleries. No bluestain occurs in logs of this type. This class of material, which is largely produced from top-killed trees or those that have been but partially infested, comprise another group that has been included in our studies.

Berry also studied the relation between the amount of degrade and the species and stages of each insect species involved in the attack. He found bluestain developed more rapidly following attack by Ips emarginatus and Dendroctonus jeffreyi. However, in the case of the latter species the difference between the effects of its attack and those of the western pine beetle are not great until the brood has developed beyond the larval stages. Flathead borers do not appear to be responsible for much bluestain until the larvae are nearly full grown.

Berry's study was preliminary, but is the only one available. On the basis of his findings, the following rough and general classification of degrade due to insect attack has been made for use in determining the spotting values and salvage values in trees and logs in relation to the composition and development of the infestation in them.

Rough Classification of Bluestain Deduction in Infested Material as related to Species of Insects and Stages of Development

*Salvage Class	Approx. % Bluestain Deduction	Insect Species	Stages
I	0	Green, uninfested	
		M. californica	Attack, eggs, small larvae
II	10	D. brevicomis	PA, Att. Eggs, small larvae
		D. monticolae	Same Stages
		I. oregoni	Same Stages
		I. emarginatus	PA, Att. Eggs, small larvae (Scattered attacks only)
		M. californica	Large larvae
III	25	D. brevicomis	Small and large larvae
		D. monticolae	Same Stages
		I. oregoni	Same Stages
		I. emarginatus	PA, Att. Eggs, small larvae
		M. californica	Prepupal larvae, pupae
IV	50	D. brevicomis	Few ½-1 larvae, mostly pupae & beyond
		D. monticolae	Same Stages
		I. oregoni	Same Stages
		I. emarginatus	Small and large larvae and beyond
		M. californica	Pupae and beyond

* Berry has used the term "Bluestain deduction class". We have used "Salvage Class" in the same sense.

The classification given above provides a rough means of estimating the reduction of salvage values in the logs that is dependent on infestation factors. The manner in which these factors affect salvage values is illustrated by Plate 3.

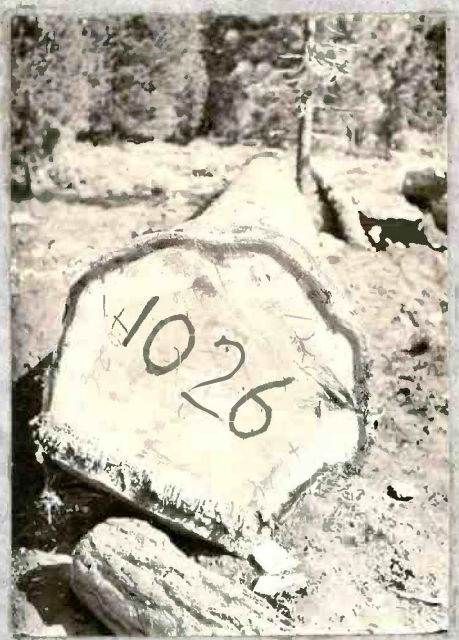
Plate 3

A

Salvage class 4 ponderosa pine abandoned by 1934 overwintering brood of the western pine beetle. Note the thick sap heavily bluestained. Lumber from the relatively small heartwood area is the only product that will be clear and bright.

B

Salvage class 4 ponderosa pine containing 1934 overwintering brood of western pine beetle. Note the thinner sap and the lighter staining.



C

Salvage class 2 ponderosa pine infested by 1935 summer generation of western pine beetle. Note the absence of any appreciable amount of bluestain.

ACCURACY OF BASAL EXAMINATIONS IN INDICATING ACTUAL DEGRADE IN TREES

The information secured by spotting crews results from basal examinations of infested trees. It is desirable that we determine the accuracy of basal examinations in indicating bluestain deductions in entire trees. It is a well known fact that basal examinations often do not indicate the nature and extent of the primary attacks that result in death of a tree. It might be expected that salvage values would vary with the infestation.

In order to determine this point all salvaged trees were given a bluestain deduction or salvage class according to the species and brood stages infesting the basal ten feet of the bole. Each tree was then divided into sixteen foot logs and the bluestain deduction class of each log was determined. The following table gives the results of those analyses:

Accuracy of classification of logs from basal examinations of infested trees

Project and Tree Species	Salvage Class of Trees	No. Trees in Sample	Total no. logs in trees	Accuracy of Classification: % of logs correctly classified	Accuracy of Classification: % of logs of equal or greater value
Fruit Growers: Ponderosa Pine	I	8	49	51	51
	II	17	64	41	72
	III	14	64	69	89
	IV	113	559	94	100
	Total	152	736	84	93
Fruit Growers: Jeffrey Pine	I	30	150	73	73
	II	23	91	54	69
	III	11	50	52	70
	IV	76	367	92	100
	Total	140	658	79	87
McCloud Ponderosa Pine	I	6	28	100	100
	II	11	59	35	42
	III	3	14	36	200
	IV	91	494	89	100
	Total	111	595	83	94
Both Projects: Both Species	I	44	227	72	72
	II	51	214	45	63
	III	28	128	59	83
	IV	280	1,410	92	100
	Total	403	1,979	83	92

This analysis shows that there may be a considerable variation in the accuracy of estimate of log values from basal examinations of infested trees. These differences appear to be associated with infestation types, tree species and salvage classes.

The accuracy of estimate in Class IV trees is high. However, there is a great range in salvage values represented by the degrade of from 50% to complete cull that is included in this class. The selection of such trees for salvage would depend on a thorough knowledge of log grades and values, and insect infestations. It appears that, in eliminating the less valuable trees of this class from the salvage process, a basal examination would be

sufficient to judge the quality of the tree and that no great amount of satisfactory merchantable material would be lost. However, control considerations may make it necessary to salvage the greater portion of the infested merchantable material in trees of this class.

THE EFFECTS OF SALVAGE LOGGING ON INFESTATIONS

A criterion of the possible effectiveness of any control measure is the amount of infested material that is removed from the woods or that is destroyed. The actual effectiveness of a measure is determined by its influence on subsequent infestations and losses. Those two points have been considered in detail in analyzing the two salvage logging projects.

One way in which a control measure may secure some regulation of losses is by preventing them. Although that point is not considered in detail in this study, the possible preventive value of salvage logging of topkilled trees is covered under "Discussion".

AMOUNT OF MATERIAL REMOVED FROM THE FOREST

Plot Data:

The two projects were directed against overwintering 1934 broods and against the 1935 summer attacks that were in the area up to the time the operations closed down. The total 1934 seasonal losses could not be salvaged. It already has been shown that abandoned trees lack sufficient value. In addition, some small trees would not, even under ordinary conditions be considered merchantable. In some cases this small sized infested material was treated by peeling and exposing the bark to the sun. The following table shows the proportions of 1934 total seasonal losses and of the 1935 losses that were found on the plot areas up to the time the operations left those plots and the amount of material that was salvaged in the course of the work.

Records of losses and materials salvaged on two study plots - (1935 figures to final date of activity on the plots)

Plot No. and Salvage Project	Year	TOTAL LOSSES		SALVAGED		%	
		Trees	Volume BM	Trees	Volume BM	% Trees	% Volume
L-15 Fruit Growers Project	1934	134	204,280	110	172,040	82	84
	1935	52	75,000	48	71,470	92	95
	Totals	186	279,280	158	243,510	85	87
MC-10 McCloud Project	1934	57	67,570	22	36,970	39	55
	1935	10	18,680	10	18,680	100	100
	Totals	67	86,250	32	55,650	48	65

It is evident that the Fruit Growers project was much more complete in its salvage of values on the plot than on the entire project area. This was due to the fact that the marking practice changed as soon as it had been determined that abandoned trees did not have sufficient value. Differences in infestation conditions on the two project areas made for a considerable difference in salvage possibilities. The grouping tendencies of the infestation

in the McCloud area lead to the infestation of smaller trees. Approximately 25% of the trees on the plot that were infested in the two seasons were smaller than 20" D.B.H. Only 5% of the trees on the Fruit Growers project were below 20" D.B.H. The higher percent of volume salvaged on the McCloud project, when compared with the lower percent of trees salvaged, is indicative of the tree size selection, that, in addition to infestation, determined salvageable values. The 1935 brood trees on the Fruit Growers project that were not salvaged are the result of leaving doubtful topkilled trees that soon became completely infested. The thorough salvage of values in 1935 trees on the McCloud project is shown in the table.

Bark Surface Data:

On both of the salvage logging operations, the infested material can be divided into two classes, i.e., that removed on the salvaged logs and that left in the woods on tops and chunks. It is necessary that the bark areas in each of these classes of material be determined if we are to be able to judge the possible effectiveness of the method as a direct control measure.

Types of bark surface: In any infestation, all the bark surface on infested trees does not contain brood. As a matter of fact not all the bark surface on infested trees is or has been infested. Accordingly, analyses of the data have been made to bring out the facts concerning the bark area uninfested, infested and abandoned as well as the proportions of surface areas of those three types that were removed in the salvage operation. These data are presented for the Fruit Growers project in Tables 1 and 2 and for the McCloud project in Table 3. The data for both projects are brought together in Table 4.

The striking point shown by these four tables is the rather close agreement of the average figures and trends on the two areas and for the two tree species. The relatively small portion of the bark surface on the boles of the infested trees that actually contained brood also is noteworthy. On the Fruit Growers project but 70.8% of the surface of salvaged ponderosa pine trees was infested. The figure was 66.5% for Jeffrey pine on that project and 68.9% for ponderosa pine on the McCloud area.

In both areas and for both tree species uninfested bark is relatively more abundant in the better salvage classes. Its abundance appears to be directly correlated with the stage of development of infestations and of insects in the trees.

An opposite trend is to be seen in the amount of abandoned bark surface. It appears that from 3 to 6% is the normal abandoned area for salvage classes having the higher values (Classes I to III) The abandoned surface in those classes is largely the result of previous topkilling infestations. In the least valuable class (IV) the normal figure is added to considerably by emergence from bole areas. This is almost entirely due to the element of time that is a common factor in the protracted period of attack usually involved before complete infestation of trees occurs.

In both areas the amount of green or uninfested bark surface that was salvaged decreased rather regularly with decrease in salvage value and

increase in stages or development of insects and infestations in the trees. The average of 89.6% on both areas, is however, rather satisfactory leaving as it does only the uninfested tops. But a small amount of the uninfested surface remained on unsalvaged chunks. A slightly smaller proportion of abandoned bark surface was salvaged - probably due to the fact that many of the older infestations represented by this type of material were of the top-killing type. The percent of infested bark surface salvaged ranged from 85% to 92% and averaged about 89%. When it is considered that but a few brood trees were missed, the direct control possibilities of salvage logging appear to be much greater than had been expected.

Infestation by species: A more detailed analysis has been made of the infested bark surface in order to determine the reductions of populations of the several insect species involved in the infestations. Tables 5 and 6 give this information for the Fruit Growers Project. Table 7 gives the figures that apply to the McCloud Project. Table 8 brings together the same information for both projects and for all the primary insect species concerned in infestation of both host trees.

It is apparent that the populations of bole infesting species were reduced to a much greater extent than were those of top infesting species. Mixed infestations, were for the most part bole infestations. The chief species concerned in this classification were the western pine beetle, mountain pine beetle, flathead borers and Ips emarginatus in ponderosa pine. The Jeffrey pine beetle replaced the western and mountain pine beetles in infestations of this type in Jeffrey pine. Salvage of mixed infestations averaged 92.3%. It is to be noted that the figure is much lower for the McCloud project. This is due to the fact that much of the mixed infestation on that area was of the fill-in type and chiefly occurred as 1935 infestations in uninfested phloem left in the tops of trees by the partial attacks of 1934 overwintering western pine beetle broods.

Utilization of bark containing the western pine beetle broods was over 90% as was that of bark containing mountain pine beetle broods. The turpentine beetle was a minor factor in the infestations but, being a base infesting insect, was salvaged in the butt logs.

It is to be noted that populations of the top infesting species (Melanophila californica and Ips pregeni) and the upper bole infesting species (Ips emarginatus) were reduced to a much greater extent in Jeffrey than in ponderosa pine. This is because infestations by those species in that host tree extended much farther down the bole than they did in ponderosa pine.

Survival of Broods in Tops and Chunks:

Studies of the survival of broods in the unsalvaged tops and chunks is necessary in order to determine the direct control value of the work. Much more information on the habits of many of the insects than is available is needed if we are to judge the relative hazard to green trees resulting from leaving infested material in the woods. It would be unwise to overlook this factor of hazard but it would be equally unwise to impose unnecessary measures on salvage logging operators until something more definite concerning the habits and potentialities of the several species are known.

The amount of infested material left in the woods was not great. This can be determined by referring to Tables 1 to 4. Few infested chunks were left on either project area. Unmerchantable tops and limbs consituted practically all the infested material in the salvaged trees that was not taken. A typical top is shown in Figure 3.(see Page 17). In this instance 17 feet that was infested by a 1935 brood of the Oregon engraver beetle lay on the ground exposed to the sun. It is to be supposed that, as much of the infested material was exposed to the sun and subject to drying out due to the fact the limbs were not lopped, little brood in infested material of this type would develop successfully and emerge.

Figure 4 (see Page 17) shows all that remained in the woods after merchantable materials in a large 40 inch ponderosa pine had been snaked from its bed. About 18 feet of top infested by overwintering broods of the western pine beetle and Oregon engraver beetle remained in a shaded position. Subsequent observations have indicated that emergence of broods of this type would be nearly normal. The figure illustrates the relatively small amount of material that was left in the form of top and limbs. In addition, it shows the relatively slight amount of injury to adjacent trees and reproduction that had been caused by snaking the bole from its bed as it lay at the proper angle to the main cat trail.

No detailed study of the broods, such as is necessary to accurately determine their success in tops and chunks, was made on either project. However, a number of scattered observations on both Jeffrey and ponderosa pine were made on the two project areas with the following results:

Western pine beetle:--1934 overwintering broods appeared to emerge in nearly normal numbers from the material left in the woods. However, in but one of the 16 cases examined were 1935 broods of this species successful in their development.

Ips emarginatus:--This species appeared to be successful in developing broods in tops left by the salvage operations.

Ips oregoni:--Definite indications of brood mortality due to the heat of the sun were found in 20 percent of the tops examined. Otherwise, the greater portion of the brood of this species in unsalvaged material appeared to be developing normally.

Melanophila californica:--Larvae of 1935 broods appeared to develop normally in uninfested phloem left by the logging operation. However, the species probably was M. gentilis and not that which normally attacks standing trees. The observation that pupae and new adults were killed in tops containing 1934 overwintering broods raises some question as to the complete success of M. californica in down material. The dead individuals found appeared to have been killed by high temperatures.

As stated before, a considerable amount of study must be performed on this phase of the work before conclusive results can provide a basis for a formulation of methods of handling the tops and chunks on salvage projects.

Figure 3

Top of tree #63, a Jeffrey pine containing 1935 broods of the Oregon engraver beetle in the 17 feet that was left in the woods.

Figure 4

Bed of tree #64, a 40-inch ponderosa pine salvaged on the Fruit Growers project. Note small amount of material left as tops and limbs and small amount of damage caused to adjacent living trees.

CONTROL EFFECTS OF SALVAGE WORK

It is possible, at this time, to give preliminary results of the salvage work as it effects a regulation of forest insect infestations. Final results can not be given until subsequent cruises can be made of the remaining 1935 losses and those of 1936.

It has been pointed out that a large part of the infested bark surface was removed and that the populations of some species of primary forest insects were reduced to a greater extent than were those of dher species. Cruises of the study plots on both projects were made later in the season in order to determine of any control effects were apparent.

On the Fruit Growers project the cruise of the salvage plot (L-15) was made during the first part of September. A nearby plot (L-3) that was treated during the winter of 1934-35 was cruised at the same time as were several other plots that were used as checks. The cruised 1935 losses on these check plots, which are not complete seasonal losses, showed that a normal infestation at the time the cruising was done was about 75% of the total 1934 seasonal loss. The treated plot (L-3) had a loss of but 41% of its 1934 loss. The salvage plot had a loss of but 48% of its 1934 loss. Of that amount all but 27 trees having a volume of but 19,620 BM was utilized. Preliminary cruise results, which are shown in Figure 5 (see Page 19) indicate marked effects both from direct control and from salvage control. Due to differences in the timing of the two types of work a direct comparison of the control effected is not possible at this time.

On the McCloud project similar satisfactory results were obtained. Figure 6 (See page 19a) illustrates the conditions on the salvage plot as compared to a nearby untreated one. The following table gives the data:

1935 Cruise Losses on Treated and Untreated Plots
McCloud project - Modoc National Forest

Time or season	Infestation Conditions on Plots			
	Salvaged Plot		Untreated Plot	
	Trees	Volume B.M.	Trees	Volume B.M.
Total 1934 loss	57	67,570	71	57,920
Loss before salvage 1935	10	18,680	No losses found	
Loss after salvage 1935 (incomplete)	9	8,300	23	23,610

The above results appear to show a considerable direct control effect of the work.

DISCUSSION

We have discussed the methods used on the Fruit Growers and McCloud projects and the factual data secured by a study of these projects. It is evident that some salvaged material was well worth taking. It also is certain

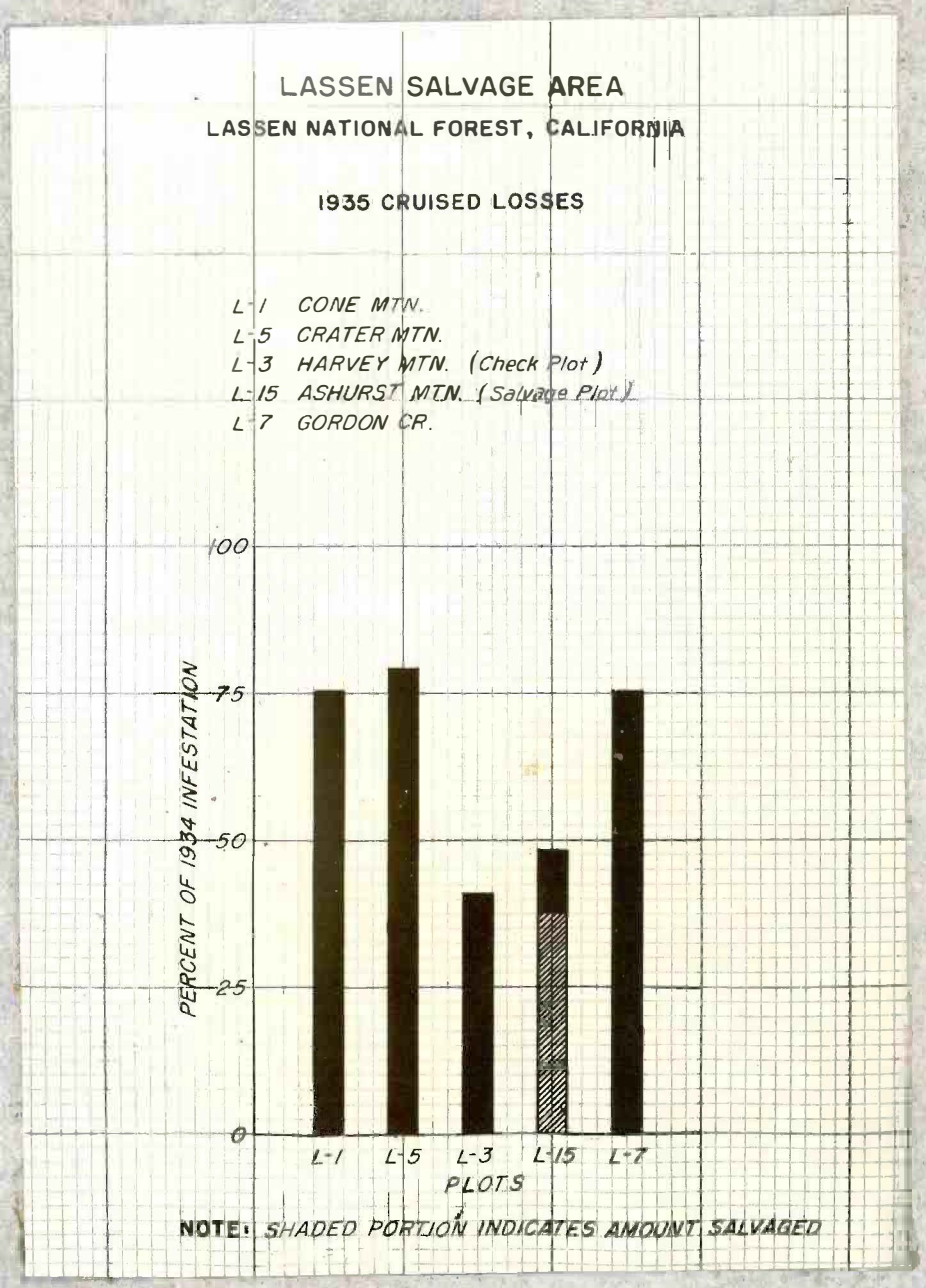


Figure 5

Comparison of 1935 losses on untreated plots with those on a plot treated in the Black's Mountain Insect Control Project of 1934-35 and one covered by the salvage logging operation of the Fruit Growers Supply Company, Lassen NF.

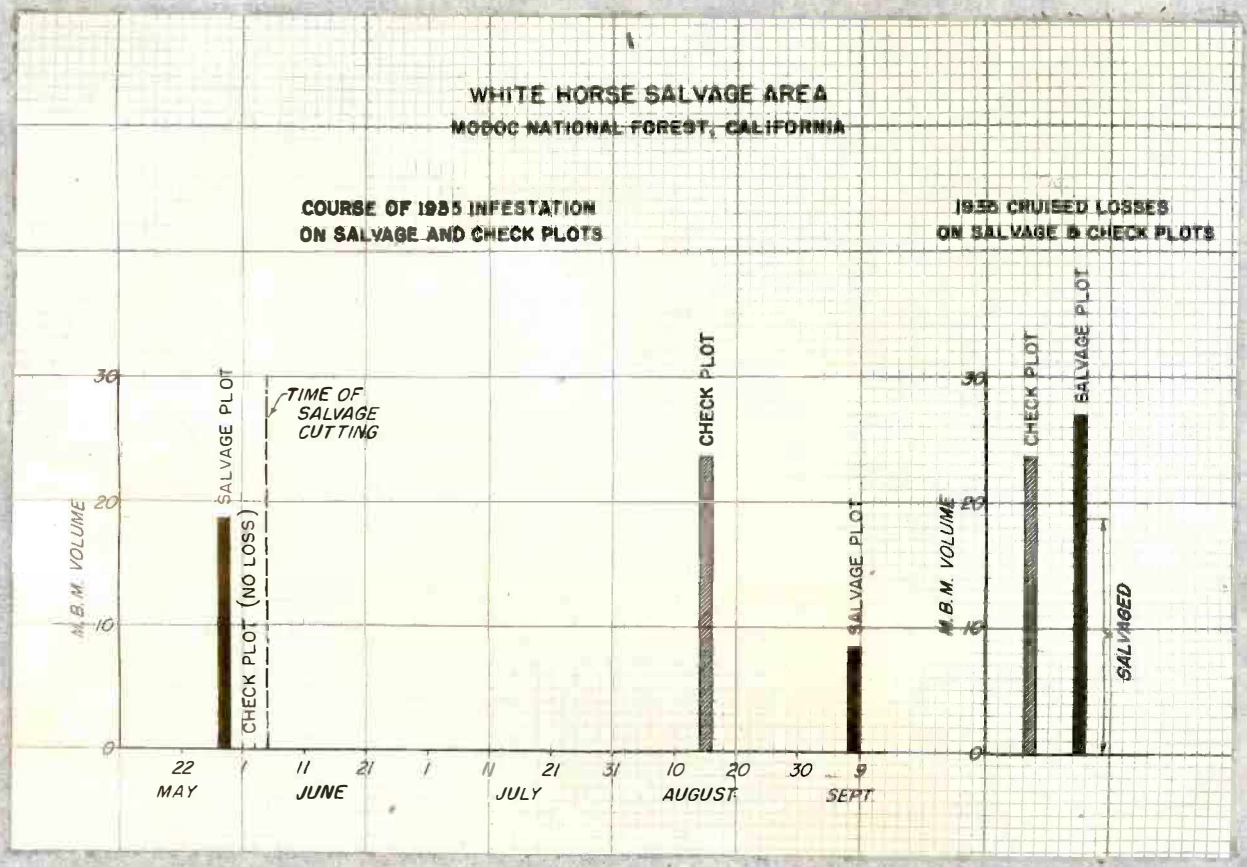


Figure 6

Comparison of losses on an untreated plot and one covered by the McCloud River Lumber Company's salvage logging project, Modoc National Forest.

that the values existing in some other salvaged logs were not sufficient to pay for the work. It has also been shown that some direct control values exist in the salvage logging operation. However, there are several other points, not founded on factual data secured on this project, that may have an important bearing on the practicability of conducting salvage logging operations as a regular practice in the management of east side forests.

Berry's cost studies have indicated that a salvage of about 400 B.M. per acre is workable from the logging standpoint. However, few infestations reach this high loss figure and, when they do, not all the infested material is worth salvaging. There appears to be little possibility of combatting the smaller but no less important losses unless the salvage of smaller amounts of timber per unit area can be considered good practice. Unless that is true, it would be difficult to attack infestation cycles before the force of the infestations had become too great to divert them from their original course.

Salvage of Susceptible Trees:

If salvage logging of small amounts of timber is considered worthwhile, we may approach an extreme type of selection logging. It would be foreign to the present logging practice. This degree of development in management and practice, which would involve the cutting and utilization of infested trees as they occur, is a little too much to hope for for some time to come. Even if the control values of this type of operation could be considered sufficient to balance the cost, it is probable that the method would be applied only in selected valuable stands. However, if in addition to the infested material, highly susceptible trees could be removed, some prevention of subsequent losses might be secured and the volume of timber salvaged per unit area would be raised to a satisfactory level.

Because of practical considerations involved, a light cut, as advocated by Keen (6*) is not considered advisable. However, infestation studies have shown that topkilled trees are much more susceptible to subsequent insect attack and complete infestation than are those not so infested. In addition, a large number of the completely infested trees that have been analyzed during the past five years have shown definite or implied evidences of previous topkilling. In east side areas topkilled material is rather abundant. Many trees that do not have the typical fade of topkilled trees often have a considerable amount of infestation. It is suggested that, if completely infested trees will not supply a sufficient amount of material, topkilled trees may be taken to fill in to a profitable level. If indications of the importance of topkilled trees and the activities of topkilling species of forest insects in causing losses are correct, a considerable preventive effect also should be secured by this selection of material for salvage. If preventive effects can be secured it would pay to consider topkilled trees as satisfactory material for salvage regardless of the amount of infested material available.

6* Keen, F. P. Relative Susceptibility of Ponderosa Pines to Barkbeetle Attack. June, 1935.

Maintenance Control:

So far as is known no insect control work had been done on the Fruit Growers project area previous to 1935. In 1931 an insect control project included the area that was covered by the McCloud project in 1935. Under many conditions direct control projects have to be repeated in the form of maintenance control work. This is due to the fact that the direct control method merely reduces the population of forest insects in an area and does not effect other and possibly more basic factors.

It is to be expected that, under critical environmental conditions, there will be some need for maintenance salvage of infested timber. When infested trees alone are considered for salvage the operation has no greater control possibilities than direct methods. If susceptible trees in the form of top infested trees are taken, it seems probable that a more permanent influence on infestation conditions will result. However, subsequent activities by topkilling species will provide more material of the top-killed type, and may make maintenance salvage necessary.

Whether or not salvage logging can be used on a maintenance basis will depend to a great extent on the following factors:

1. The degree of management of a stand or area.
2. The minimum volume limits set by costs of the work or amount of material available.

A considerable amount of experimental work on costs and on the amount of control secured will have to be completed before the minimum volume limits below which the method will not pay can be determined. It is felt that the degree of management that is desirable in an area also may depend to a considerable extent on that figure.

RECOMMENDATIONS

A completely successful forest insect control method should provide for prevention of losses, control of infestations and utilization of infested timber all at a profit or at least at a small cost. A good method of control should provide for at least a reasonable amount of control or prevention.

Salvage logging appears to have possibilities of securing some control and prevention in addition to providing for utilization of infested material. The cost should not be high. However, the requirements of utilization, which is an important feature of the method, may at times work to the detriment of the insect control that can be secured. There is a difficult problem to be studied that involves the relative importance of the insect control/and the satisfactory financial balance of the utilization process.

Besides this problem, which needs a considerable amount of study from standpoints of management, utilization and forest insect control there are many other problems on which future study is necessary.

Many problems it will be necessary to solve before the true value of the method can be appraised are not yet known. However, some of these that are known to be concerned with the entomological phases of determining the control value of the work are as follows:

1. The importance of broods in unsalvaged material.
2. The control values of salvage logging under different conditions.
3. The importance of population reduction of the different insect species.
4. The preventive possibilities of the method.
5. The tree selection problem.
6. The point of balance between the satisfactory minimum limits of salvage for control and salvage for economic utilization.

SUMMARY

Two salvage control projects were studied in 1935. One, the Fruit Growers project on the Lassen National Forest, was studied by the Forest Service, Forest and Range Experiment Station and the Bureau of Entomology and Plant Quarantine to secure data on methods, costs, products and control. Only the entomological phases were studied on the McCloud project in the Modoc National Forest.

The results of studies on methods, costs and products were not covered by this report except as they are concerned with the study of entomological phases of the projects.

The infestation was rising on the Fruit Growers project area but the peak of an infestation cycle had been reached on the McCloud area. Both ponderosa and Jeffrey pine were salvaged on the former project but Jeffrey pine did not occur in the stands on the Modoc area.

The objectives of the entomological work were (1) to determine if tree values could be estimated with fair accuracy on the basis of spotting data; (2) to determine the relations of infestation and amount of cull; and (3) to determine the effects of the salvage logging method on infestations.

It was found that basal examinations, such as are used in spotting, were of sufficient accuracy in class IV trees, which are those having the lowest salvage values, to warrant their use in eliminating those trees from the project. However, control considerations apparently make necessary the salvage of infested trees in that class.

The amount of degrade resulting from entomological factors appears to be correlated with the development of infestations in trees, the development of broods in infestations, and the insect species involved.

On both salvage projects, most of the newly infested trees (1935 broods) were removed. The proportion of trees containing 1934 overwintering broods that were removed depended to a large extent on product value considerations. However, the net results on the study plots were favorable for control.

Studies of infested bark surfaces showed that remarkably consistent results were secured from both project areas. An average of 90% of the infested bark surface and 89.6% of the uninfested bark surface was salvaged. The salvaged bark surface included that filled with brood of bole infesting and top infesting species of insects. However, the salvage ratio of bark infested by the bole infesting species was higher than the salvage ratio of bark infested by top killing insects. No exact data was secured on subsequent mortality of broods in unsalvaged tops and chunks.

On the Fruit Growers project a reduction in 1935 brood losses was secured that compared favorably with reductions secured by the 1934-35 direct control project in a nearby area. The reduction in 1935 losses that was secured on the McCloud project also indicated marked control was effected by the salvage operation.

The minimum economic limits of salvage logging may make the salvage control method relatively ineffective from the insect control standpoint unless concessions can be made. The possibility of making these concessions appears to depend on the degree of management of stands and the control that can be secured by use of the method. However, salvage of topkilled susceptible trees may be of use in satisfying economic requirements. In addition, it is probable that salvage of topkilled trees would act as an effective preventive of subsequent losses.

The problem of maintenance salvage control remains to be solved as do many other problems associated with all phases of the method.

A - Tree felled and ready for limbing and bucking. Trees were felled at about a 30 degree angle to the main cat trail to prevent injury to reproduction and living trees when they were snaked from their beds.

B - A main cat trail used to haul many of the infested trees taken from the study plot on the Fruit Growers Project area. Note the small amount of injury caused to adjacent trees and reproduction.

PLATE 5

A - Trees were taken from the woods to the landing in tree lengths. By using this method much larger loads were hauled.

B - In tree length logging it was found necessary to have almost straight main cat trails. Sometimes this only it was necessary to break through dense clumps of reproduction. However, road locations were selected so as to result in a minimum amount of injury to living trees.

A - Logs were taken to landings along the railroad where they were bucked into log lengths for loading.

B - At the landings a crane loaded the logs on flatcars after which they were taken about 45 miles to the mill at Susanville

Table 1

Total and Salvaged Area and Percent of Bark Surface Uninfested, Abandoned, and Infested

Ponderosa Pine - Fruit Growers Project - Lassen National Forest

Salvage Class	Sq.ft.	TOTAL BARK SURFACE: Uninfested Surface: Sq. ft.	% Total	Abandoned Surface: Sq. ft.	% Total	Infested Surface: Sq. ft.	% Total	SALVAGED BARK SURFACE: Uninfested Surface: Sq. ft.	% Total	Abandoned Surface: Sq. ft.	% Total	Infested Surface: Sq. ft.	% Total
I	4,156:	2,250:	54.1:	125:	3.0:	1,781:	42.9:	2,250:	100.0:	0:	0.0:	1,894:	83.9
II	9,597:	3,739:	38.9:	375:	3.9:	5,483:	57.1:	3,444:	92.1:	168:	44.8:	5,159:	94.1
III	5,948:	793:	13.3:	201:	3.4:	4,954:	83.3:	652:	82.2:	69:	34.3:	4,537:	91.6
IV	58,668:	1,189:	2.0:	14,168:	24.7:	42,991:	73.3:	928:	78.0:	10,539:	72.7:	39,560:	92.0
Totals	78,369:	7,971:		15,189:		55,209:		7,274:		10,776:			
Average:			10.2:		19.4:		70.4:		91.3:		70.9:		91.9

Table 2

Jeffrey Pine - Fruit Growers Project - Lassen National Forest

Salvage Class	Sq.ft.	TOTAL BARK SURFACE: Uninfested Surface: Sq. ft.	% Total	Abandoned Surface: Sq. ft.	% Total	Infested Surface: Sq. ft.	% Total	SALVAGED BARK SURFACE: Uninfested Surface: Sq.ft.	% Total	Abandoned Surface: Sq. ft.	% Total	Infested Surface: Sq. ft.	% Total
I	15,221:	11,236:	73.8:	458:	3.0:	3,527:	23.2	10,718:	95.4	159:	34.7	2,681:	76.0
II	11,392:	1,716:	15.1:	677:	5.9:	8,999:	79.0	1,569:	91.4	410:	60.6	8,112:	90.1
III	6,146:	2,238:	36.4:	348:	5.7:	3,560:	57.9	2,000:	89.4	50:	14.4	3,134:	88.0
IV	39,153:	2,086:	5.3:	5,359:	13.7:	31,708:	81.0	1,616:	77.5	3,862:	72.1	28,499:	89.9
TOTALS	71,912:	17,276:		6,842:		47,794:		15,903:		4,481:		42,426:	
AVERAGE			24.0:		9.5:		66.5		92.0		65.5		88.8

Table 3

Total and Salvaged Area and Percent of Bark Surface Uninfested, Abandoned, and Infested. -

Ponderosa Pine - McCloud Project - Modoc National Forest

Salvage Class	TOTAL BARK SURFACE: Uninfested Surface Sq. ft.	Uninfested Surface Sq. ft.	Uninfested Surface % Total	Abandoned Surface Sq. ft.	Abandoned Surface % Total	Infested Surface Sq. ft.	Infested Surface % Total	SALVAGED BARK SURFACE: Uninfested Surface Sq. ft.	Uninfested Surface % Total	Abandoned Surface Sq. ft.	Abandoned Surface % Total	Infested Surface Sq. ft.	Infested Surface % Total
I	3,891	2,865	73.6	163	4.2	863	22.2	2,442	85.2	0	0.0	637	73.8
II	10,168	2,833	27.9	885	8.7	6,447	63.4	2,161	76.3	564	63.5	5,289	82.0
III	6,082	918	15.1	259	4.3	4,905	80.6	785	85.5	31	12.0	4,620	94.2
IV	42,475	146	0.3	11,934	28.1	30,395	71.6	109	74.6	8,178	68.5	25,821	85.0
	62,616	6,762		13,244		42,610		5,497		8,773		36,367	
			10.8		21.1		68.9		81.3		66.2		85.3

Table 4

Total and Salvaged Area and Percent of Bark Surface Uninfested, Abandoned, and Infested -

Ponderosa and Jeffrey Pines - Fruit Growers and McCloud Projects

Salvage Class	TOTAL BARK SURFACE: Uninfested Surface Sq. ft.	Uninfested Surface Sq. ft.	Uninfested Surface % Total	Abandoned Surface Sq. ft.	Abandoned Surface % Total	Infested Surface Sq. ft.	Infested Surface % Total	SALVAGED BARK SURFACE: Uninfested Surface Sq. ft.	Uninfested Surface % Total	Abandoned Surface Sq. ft.	Abandoned Surface % Total	Infested Surface Sq. ft.	Infested Surface % Total
I	23,268	16,351	70.3	746	3.2	6,171	26.5	15,410	94.2	159	21.3	4,812	78.0
II	31,157	8,288	26.6	1,940	6.2	20,929	67.2	7,174	86.6	1,142	58.9	18,560	88.7
III	18,176	3,949	21.7	808	4.5	13,419	73.8	3,437	87.0	150	18.6	12,291	91.6
IV	140,296	3,421	2.5	31,781	22.6	105,094	74.9	2,653	77.6	22,579	71.0	93,880	89.3
Totals	212,897	32,009		35,275		145,613		28,674		24,030		129,543	
Average			15.0		16.6		68.4		89.6		68.1		90.0

Table 5

Area and percent of infested bark surface removed from woods (By insect species)

Ponderosa Pine - Fruit Growers Project - Lassen National Forest

Salv. Class	Mixed Infestations: Total Infest. sq.ft. Surf.	Total sq.ft	Salv. sq.ft	% Salv	D. brevicomis: Total sq.ft	Salv. sq.ft	% Salv	D. californica: Total sq.ft	Salv. sq.ft	% Salv	I. emarginatus: Total sq.ft	Salv. sq.ft	% Salv	I. oregoni: Tot. sqft	Salv sqft	% Salv	D. monticolae: Tot. sqft	Sal sqft	% Salv	D. valens: Tot. sqft	Salv sqft	% Salv
I	1,781	929	888	95.6	469	445	94.9	232	10	4.3	134	134	100.0	--	--	0.0	17	17	100.0			
II	5,483	2,705	2,658	98.3	1,094	1,049	95.9	739	524	70.9	200	200	100.0	--	--	0.0	621	604	97.3	124	124	100
III	4,954	3,402	3,310	97.3	1,074	1,040	96.8	427	187	43.8	32	0	0.0	19	9	0.0	--	--	0.0			
IV	42,991	18,287	17,131	93.7	19,369	18,698	96.5	2,883	2,172	75.3	1,797	1,345	74.8	511	70	13.7	144	144	100.0			
Totals	55,209	25,323	23,987		22,006	21,232		4,281	2,893		2,163	1,679		530	79		782	765		124	124	
Aver.				94.7			96.5			67.6			77.6			13.2			97.8			100

Table 6

Area and percent of infested bark surface removed from woods (By insect species)

Jeffrey Pine - Fruit Growers Project - Lassen National Forest

Salv. Class	Mixed Infestations: Total Infest. sq.ft. Surf.	Total sq.ft.	Salv. sq.ft	% Salv	D. jeffreyi: Total sq.ft	Salv. sq.ft	% Salv	D. californica: Total sq.ft	Salv. sq.ft	% Salv	Ips emarginatus: Total sq.ft	Salv. sq.ft.	% Salv	Ips oregoni: Tot. sqft	Salv. sqft	% Salv
I	3,527	428	195	45.6	235	235	100.0	2,549	2,087	81.9	114	114	100.0	201	50	24.9
II	8,999	2,235	2,063	92.3	2,969	2,665	89.8	3,243	2,878	88.7	506	506	100.0	46	0	0.0
III	3,560	1,974	1,912	96.9	0	0	0	767	494	64.4	743	698	93.9	76	30	39.5
IV	31,708	15,269	17,263	94.5	3,985	3,985	100.0	7,742	6,090	81.5	588	467	79.4	1,394	694	50.0
Totals	47,794	23,906	21,433		7,189	6,885		14,031	11,549		1,951	1,785		1,717	744	
Aver.				93.6			95.8			82.3			91.5			45.1

Table 7

Area and percent of infested bark surface removed from woods (By insect species)

Ponderosa Pine - McCloud Project - Modoc National Forest

Salvage Class	Total Infested Surface in sq.ft.	Mixed Infestation Total sq.ft.	Mixed Infestation Salv. sq.ft.	Mixed Infestation Salv. %	Dendroctonus brevicomis Total sq.ft.	Dendroctonus brevicomis Salv. sq.ft.	Dendroctonus brevicomis Salv. %	Melanophila californica Total sq.ft.	Melanophila californica Salv. sq.ft.	Melanophila californica Salv. %	Ips emarginatus Total sq.ft.	Ips emarginatus Salv. sq.ft.	Ips emarginatus Salv. %	Ips oregoni Total sq.ft.	Ips oregoni Salv. sq.ft.	Ips oregoni Salv. %	Dendroctonus monticolae Total sq.ft.	Dendroctonus monticolae Salv. sq.ft.	Dendroctonus monticolae Salv. %
I	863	0	0	0.0	0	0	0.0	863	637	73.8	0	0	0.0	0	0	0.0	0	0	0.0
II	6,447	3,258	2693	82.7	2,442	2,270	92.9	203	63	31.0	383	213	55.6	111	0	0.0	50	50	100.0
III	4,905	2,479	2832	96.1	2,105	2,076	98.6	115	46	40.0	87	53	60.9	119	63	52.9	0	0	0.0
IV	30,395	4,537	3425	75.5	23,371	21,264	91.0	139	54	38.8	829	527	63.6	1,308	340	26.0	211	211	100.0
TOTALS	42,610	10,274	8500		27,918	25,610		1320	800		1299	793		1,538	403		261	261	
AVERAGE:		24.1		82.7	65.5		91.7	3.1		60.6	3.0		61.0	3.6		26.2	0.6		100.0

Table 8

Area and percent of infested bark surface removed from woods (By insect species)

Fruit Growers and McCloud Projects - Ponderosa & Jeffrey Pine

Salvage Class	Total Infested Surface in sq.ft.	Mixed Infestation Total sq.ft.	Mixed Infestation Salv. sq.ft.	Mixed Infestation Salv. %	Dendroctonus brevicomis Total sq.ft.	Dendroctonus brevicomis Salv. sq.ft.	Dendroctonus brevicomis Salv. %	Dendroctonus jeffreyi Total sq.ft.	Dendroctonus jeffreyi Salv. sq.ft.	Dendroctonus jeffreyi Salv. %	Melanophila californica Total sq.ft.	Melanophila californica Salv. sq.ft.	Melanophila californica Salv. %
I	6,171	1,357	1,083	79.8	469	445	94.9	235	235	100.0	3,644	2,734	75.0
II	20,929	8,198	7,414	90.4	3,536	3,319	93.9	2,969	2665	89.8	4,185	3,465	82.8
III	13,419	7,855	7,604	96.8	3,179	3,116	98.0	0	0	0	1,309	727	55.5
IV	105,094	41,093	37,819	92.0	42,740	39,962	93.5	3,985	3985	100.0	10,494	8,316	79.2
TOTALS	145,613	58,503	53,920		49,924	46,842		7,189	6885		19,632	15,242	
AVERAGE:				92.3			93.8			95.8			77.6